IMPROVED HARVEST INDEX IN DROUGHT RESISTANT COMMON BEANS AND POSSIBLE EFFECTS ON COMBINING ABILITY

Stephen Beebe, Idupulapati Rao, José Polonía, Miguel Grajales, and César Cajiao

International Center for Tropical Agriculture (CIAT), A.A. 6713, Cali, Colombia
(E-mail: s.beebe@cgiar.org)

INTRODUCTION

Crop improvement has often resulted in enhanced harvest index, especially in the cereals. Poor harvest index is a characteristic of wild ancestors of crops, which often display survival mechanisms that are contrary to maximizing grain yield (Evans, 1993; Richards, 1997). Wild bean is a case in point. The wild bean ancestor of common bean germinates in a weedy environment among small trees and shrubs at the onset of seasonal rains, and must quickly develop a guide and climb to the top of the surrounding canopy to survive in a competitive environment. In this phase seed production must be suppressed until vegetative growth has assured access to light at the top of the canopy. Cultivated common bean may still have a delicate balance between vegetative and reproductive phases, and is prone to excessive vegetative growth and low harvest index, for example, in conditions of abundant soil moisture and adequate soil fertility. Thus, improving sink strength and harvest index may be a major challenge of genetic improvement of yield potential and abiotic stress tolerance of common bean.

MATERIALS AND METHODS

Drought resistant common bean lines in the small red (SER), small black (NCB), and carioca (SXB) classes were developed at the International Center for Tropical Agriculture (CIAT) in Cali, Colombia. Parental materials combined sources derived from race Durango, as well as small red seeded lines of race Mesoamerica. Several lines outyielded commercial checks of the same class and were identified as drought resistant for more intensive physiological study. Results of 20 genotypes (SER 47, SER 78, SER 109, SER 118, SER 119, SER 125, SER 128, SXB 405, SXB 409, SXB 412, SXB 418, NCB 226, NCB 280, RCB 273, Tio Canela 75, Carioca, SER 16, SEA 5, Pérola and DOR 390) are reported here. Tio Canela was included as a small red check, and DOR 390 as a black seeded check. Lines were planted in the July-September 2006 dry season under conditions of adequate soil moisture (irrigated) and terminal drought. A 4 x 5 partially balanced lattice design with 3 replicates was used. A number of plant attributes including canopy temperature, leaf area index, canopy dry weight, pod harvest index (dry wt of pods/dry wt of total biomass at mid-podfill x 100), grain yield and yield components were determined. Pod harvest index is used as a surrogate for harvest index (HI) because leaf fall at maturity makes HI difficult to measure accurately. Root growth and distribution (0-60 cm soil depth) were determined for four genotypes: SEA 5, Tio Canela 75, SER 16 and DOR 390.

SER 16 has expressed excellent combining ability, readily transmitting its characteristics of drought resistance, short bush habit, and productive branching. Therefore, SER 16 was employed in backcross-1 populations of (SER 16 x (SER 16 x *P. coccineus*)) for improving resistance to aluminum toxicity, using three different accessions of *P. coccineus* (runner bean). Individual plant selections were made within these populations and were progeny tested in the F_3 generation under aluminum toxic soil conditions.

RESULTS AND DISCUSSION

The data on pan evaporation together with rainfall distribution indicated that the crop suffered significant terminal drought stress during active growth and development. The mean yield under rainfed conditions was 1876 kg/ha compared with the mean irrigated yield of 2940 kg/ha. Among the 20 lines tested, three lines SXB 418, SER 109 and NCB 280 were outstanding in their adaptation to rainfed (water stress) conditions while Tio Canela 75, Pérola and Carioca were the most poorly adapted. Many lines including SER 16 showed improved pod harvest index. SER 109 was particularly outstanding in its ability to partition greater proportion of biomass to pods (Figure 1). The superior adaptation of SXB 418 to drought stress was associated with greater canopy biomass and lower pod harvest index. SER 78 had greater pod harvest index but average seed yield under drought due to greater proportion of pod wall biomass to grain yield. In contrast, results on root growth indicated that drought sensitive Tio Canela and DOR 390 were more deep rooted than the drought adapted SER 16 and SEA 5, suggesting that root growth occurred at the expense of photosynthate mobilization to seed under drought stress.

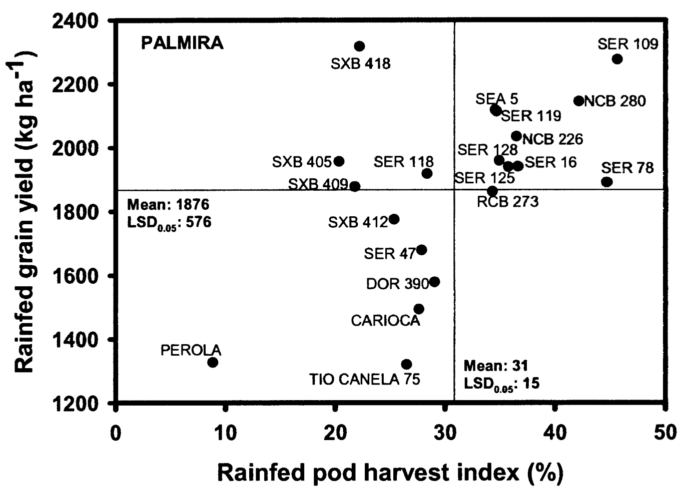

Figure 1. Identification of genotypes that combine superior seed yield with superior pod harvest index (upper right quadrant) under rainfed conditions in a Mollisol at Palmira.

Among the backcross-1 progeny of SER 16, productive plants were identified in all populations and progeny tested. Families from the cross with G 35346 were especially productive, expressing the positive traits of SER 16 (compact plant habit, productivity), but much improved resistance to aluminum toxicity over SER 16. We suggest that the combining ability of SER 16 is related to its ability to mobilize photosynthates to seed, resulting in enhanced HI. Furthermore, in the crosses with runner bean this trait may have contributed to improved quality of interspecific progeny, combining the typically large biomass of runner bean with improved harvest index of SER 16. Therefore, SER 16 may offer an option for introgressing traits from runner bean, leading to wider use of this genetic resource.

REFERENCES

Evans, L.T. 1993. Crop evolution, adaptation and yield. Cambridge University Press, Cambridge, UK.

Richards, R.A. 1997. Defining selection criteria to improve yield under drought. In: Belhassen E (ed), Drought Tolerance in Higher Plants: Genetical, Physiological and Molecular Biological Analysis, pp.79-88. Kluwer Academic Publishers, Dordrecht, The Netherlands.